

Supplementary File

**Identifying characteristics that enable resilient immunization programs:
a scoping review**

Baxter et al.

S1. Supplementary methods

S1.1. Research question

The research questions that we addressed were: (i) is the Health System Resilience Index suitable for assessing immunization program resilience? and (ii) what are the major gaps in primary empirical research in assessing immunization program resilience?

Table S1: Research question in PICO format

Population	Immunization programs
Intervention	Crises, shocks, or disruptions
Comparator	n/a
Outcome	Strength, or resilience, or topics aligned with the concept of immunization program strength or resilience during a time of crisis, as described in the titles and abstracts of screened records

S1.2. Eligibility criteria

Table S2: Inclusion criteria

Population	Immunization programs
Intervention	Crises, shocks, or disruptions
Comparator	n/a
Outcome	Strength, or resilience, or topics aligned with the concept of immunization program strength or resilience during a time of crisis, as described in the titles and abstracts of screened records
Study design	Any study design e.g., experimental, observational, controlled, uncontrolled.
Report characteristics	Primary empirical peer-reviewed studies; published from 1 st January 2011 onwards

Table S3: Exclusion criteria

Population	Immunization programs or vaccinations for non-human species
Intervention	n/a
Comparator	n/a
Outcome	n/a
Study design	n/a
Report characteristics	Secondary literature (e.g. reviews) and non-empirical literature (e.g. opinions, commentaries, perspectives); un-published non-peer reviewed records (e.g. conference abstracts, meeting reports); publications earlier than 1 st January 2011.

S1.3. Search strategies

MEDLINE (Ovid)

1. ((immuni* or vaccin*) adj4 (program* or system* or service* or deliver* or routine* or uptake* or up-take* or coverage*)).ti,ab,kf.
2. exp immunization/ and (program* or system* or service* or deliver* or routine* or uptake* or up-take* or coverage*).ti,ab,kf.
3. exp immunization programs/ or vaccination coverage/
4. 1 or 2 or 3
5. exp program evaluation/ or (resilien* or strengthen*).ti,ab,kf.
6. 4 and 5
7. (review or "scientific integrity review" or "systematic review" or meta-analysis or "case reports" or editorial).pt. or (systematic review or meta-analys* or case report* or editorial).ti.
8. exp animals/ not humans/
9. 7 or 8
10. 6 not 9
11. limit 10 to yr="2011 -Current"

Embase (Ovid)

1. ((immuni* or vaccin*) adj4 (program* or system* or service* or deliver* or routine* or uptake* or up-take* or coverage*)).ti,ab,kf.
2. exp immunization/ and (program* or system* or service* or deliver* or routine* or uptake* or up-take* or coverage*).ti,ab,kf.
3. vaccination coverage/
4. 1 or 2 or 3
5. exp program evaluation/ or (resilien* or strengthen*).ti,ab,kf.
6. 4 and 5
7. (review or editorial or conference abstract).pt. or (systematic review or meta-analys* or case report* or editorial).ti.

8. (exp animal/ or nonhuman/) not exp human/
9. 7 or 8
10. 6 not 9
11. limit 10 to yr="2011 -Current"

PsycINFO (Ovid)

1. ((immuni* or vaccin*) adj4 (program* or system* or service* or deliver* or routine* or uptake* or up-take* or coverage*)).mp.
2. exp immunization/ and (program* or system* or service* or deliver* or routine* or uptake* or up-take* or coverage*).mp.
3. 1 or 2
4. program evaluation/ or (resilien* or strengthen*).mp.
5. 3 and 4
6. (systematic review or meta-analys* or case report* or editorial).ti.
7. 5 not 6
8. limit 7 to yr="2011 -Current"

CINAHL (EBSCO)

1. TI ((immuni* or vaccin*) N3 (program* or system* or service* or deliver* or routine* or uptake* or up-take* or coverage*)) OR AB ((immuni* or vaccin*) N3 (program* or system* or service* or deliver* or routine* or uptake* or up-take* or coverage*)) OR SU ((immuni* or vaccin*) N3 (program* or system* or service* or deliver* or routine* or uptake* or up-take* or coverage*))
2. (MH "Immunization+")
3. TI (program* or system* or service* or deliver* or routine* or uptake* or up-take* or coverage*) OR AB (program* or system* or service* or deliver* or routine* or uptake* or up-take* or coverage*) OR SU (program* or system* or service* or deliver* or routine* or uptake* or up-take* or coverage*)
4. S2 AND S3
5. (MH "Immunization Programs")

6. (MH "Vaccination Coverage")
7. S1 OR S4 OR S5 OR S6
8. (MH "Program Evaluation")
9. TI (resilien* or strengthen*) OR AB (resilien* or strengthen*) OR SU (resilien* or strengthen*)
10. S8 OR S9
11. S7 AND S10
12. PT "systematic review" OR meta-analys* OR "case report*" OR editorial OR review
13. TI "systematic review" OR meta-analys* OR "case report*" OR editorial
14. (MH "Animals+") NOT (MH "Human")
15. S12 OR S13 OR S14
16. S11 NOT S15
17. S11 NOT S15 (Limiters - Published Date: 20110101-20231231)

CENTRAL (Wiley)

1. ((immuni* or vaccin*) NEAR/3 (program* or system* or service* or deliver* or routine* or uptake* or up-take* or coverage*)) :ti,ab,kw
2. [mh "Immunization"]
3. (program* or system* or service* or deliver* or routine* or uptake* or up-take* or coverage*) :ti,ab,kw
4. #2 and #3
5. [mh "Immunization Programs"]
6. [mh ^"Vaccination Coverage"]
7. #1 OR #4 OR #5 OR #6
8. [mh "Program Evaluation"]
9. (resilien* or strengthen*) :ti,ab,kw

10. #8 OR #9

11. #7 AND #10

12. #7 AND #10 (with Cochrane Library publication date from Jan 2011 to Dec 2023)

Web of Science Core Collection: SCI-EXPANDED and SSCI (Clarivate Analytics)

1. TS=((immuni* or vaccin*) NEAR/3 (program* or system* or service* or deliver* or routine* or uptake* or up-take* or coverage*))
2. TS=(resilien* or strengthen*)
3. #1 AND #2
4. DT=(Review or Editorial Material or Early Access or Letter or Proceedings Paper)
5. TI=(systematic review or meta-analys* or case report* or editorial)
6. #4 OR #5
7. #3 NOT #6
8. DOP=(2011-01-01/2023-12-31)
9. #7 AND #8

Google Scholar (Publish or Perish)

Title words:

resilience|resiliency|resilient|strengthen|strengthening

vaccination|vaccinate|vaccines|vaccine|immunisation|immunization|immunise|immunize

Years:

2011 - 2024

Maximum number of results:

200

S2. Supplementary results

Table S4: Study characteristics

Bibliographic details		Study location		Study design		Crisis		Resilience characteristic discussed
Author (year)	Title	Continent	Country	Level 1	Level 2	PESTLE	Specific crisis	
Anderberg (2011) ¹	Anatomy of a health scare: education, income and the MMR controversy in the UK	Europe	England	Observational	Descriptive	Social	Negative media coverage Public trust/fear	Awareness
Chantler (2016) ²	"It's a complex mesh"- how large-scale health system reorganisation affected the delivery of the immunization programme in England: a qualitative study	Europe	England	Observational	Descriptive	Legal	Health system reorganization	Awareness, Integration, Resource Availability and Access, Self-regulation
Camara (2017) ³	Influence of the 2014-2015 Ebola outbreak on the vaccination of children in a rural district of Guinea	Africa	Guinea	Observational	Descriptive	Environmental	Ebola outbreak	Awareness, Integration, Resource Availability and Access, Self-regulation
Delamou (2017) ⁴	Effect of Ebola virus disease on maternal and child health services in Guinea: a retrospective observational cohort study	Africa	Guinea	Observational	Descriptive	Environmental	Ebola outbreak	Integration, Resource Availability and Access
Habib (2017) ⁵	Community engagement and integrated health and polio immunization campaigns in conflict-affected areas of Pakistan: a cluster randomised controlled trial	Asia	Pakistan	Experimental	RCT	Social	Insecurity / armed conflict	Adaptiveness, Awareness, Integration, Resource Availability and Access, Self-regulation
Mussah (2017) ⁶	Performance-based financing contributes to the resilience of health services affected by the Liberian Ebola outbreak	Africa	Liberia	Observational	Analytical	Environmental	Ebola outbreak	Resource Availability and Access
Sun (2017) ⁷	Impact of the Ebola outbreak on routine immunization in western area, Sierra Leone - a field survey from an Ebola epidemic area	Africa	Sierra Leone	Observational	Descriptive	Environmental	Ebola outbreak	Integration, Self-regulation

Tohme (2017) ⁸	Expansion of Vaccination Services and Strengthening Vaccine-Preventable Diseases Surveillance in Haiti, 2010–2016	North America	Haiti	Observational	Descriptive	Environmental	Earthquake	Resource Availability and Access
Suppli (2018) ⁹	Decline in HPV-vaccination uptake in Denmark - the association between HPV-related media coverage and HPV-vaccination	Europe	Denmark	Observational	Descriptive	Social	Negative media coverage Public trust/fear	Awareness, Integration
Akseer (2019) ¹⁰	Association of Exposure to Civil Conflict with Maternal Resilience and Maternal and Child Health and Health System Performance in Afghanistan	Asia	Afghanistan	Observational	Descriptive	Social	Insecurity / armed conflict	Awareness, Integration, Resource Availability and Access
Chantler (2019) ¹¹	Is partnership the answer? Delivering the national immunization programme in the new English health system: a mixed methods study	Europe	England	Observational	Descriptive	Legal	Health system reorganization	Adaptiveness, Awareness, Integration, Resource Availability and Access, Self-regulation
Clarke (2019) ¹²	Strengthening immunization service delivery post Ebola virus disease (EVD) outbreak in Liberia 2015-2017	Africa	Liberia	Observational	Analytical	Environmental	Ebola outbreak	Adaptiveness, Awareness, Integration, Resource Availability and Access
Okuhara (2019) ¹³	Newspaper coverage before and after the HPV vaccination crisis began in Japan: a text mining analysis	Asia	Japan	Observational	Descriptive	Social	Negative media coverage Public trust/fear	Awareness, Integration
Alsuhaibani (2020) ¹⁴	Impact of the COVID-19 Pandemic on Routine Childhood Immunization in Saudi Arabia	Asia	Saudi Arabia	Observational	Descriptive	Environmental	COVID-19 outbreak	Adaptiveness, Awareness, Integration, Resource Availability and Access
Dayrit (2020) ¹⁵	The importance of effective risk communication and transparency: lessons from the dengue vaccine controversy in the Philippines	Asia	Philippines	Observational	Descriptive	Political Social	Poor communication and transparency Public trust/fear	Awareness, Integration, Resource Availability and Access
Gørtz (2020) ¹⁶	The contagious nature of a vaccine scare: How the introduction of HPV vaccination lifted and eroded MMR vaccination in Denmark	Europe	Denmark	Observational	Analytical	Social	Negative media coverage Public trust/fear	Awareness, Integration
Hansen (2020) ¹⁷	Resilience of HPV vaccine uptake in Denmark: Decline and recovery	Europe	Denmark	Observational	Descriptive	Social	Negative media coverage Public trust/fear	Adaptiveness, Awareness,

								Integration
Colón-López (2021) ¹⁸	Effect of Hurricane Maria on HPV, Tdap, and meningococcal conjugate vaccination rates in Puerto Rico, 2015–2019	North America	Puerto Rico	Observational	Analytical	Environmental	Hurricane	Adaptiveness, Resource availability and access
Falkenstein-Hagander (2021) ¹⁹	National Swedish survey showed that child health services and routine immunization programmes were resilient during the early COVID-19 pandemic	Europe	Sweden	Observational	Descriptive	Environmental	COVID-19 outbreak	Adaptiveness, Awareness, Integration, Resource Availability and Access
Hansen (2021) ²⁰	A Dynamic Model of Vaccine Compliance: How Fake News Undermined the Danish HPV Vaccine Program	Europe	Denmark	Observational	Descriptive	Social	Negative media coverage Public trust/fear	Awareness, Integration
Harris (2021) ²¹	Impact of COVID-19 on routine immunization in South-East Asia and Western Pacific: Disruptions and solutions	Asia and Australia	19 countries	Observational	Descriptive	Environmental	COVID-19 outbreak	Adaptiveness, Awareness, Integration, Resource Availability and Access
Jain (2021) ²²	COVID-19 related immunization disruptions in Rajasthan, India: A retrospective observational study	Asia	India	Observational	Analytical	Environmental	COVID-19 outbreak	Adaptiveness
Khatiwada (2021) ²³	Impact of the first phase of COVID-19 pandemic on childhood routine immunization services in Nepal: a qualitative study on the perspectives of service providers and users	Asia	Nepal	Observational	Descriptive	Environmental	COVID-19 outbreak	Adaptiveness, Awareness, Integration, Resource Availability and Access
Luna-Pinto (2021) ²⁴	Restoring Immunization Services Provided by the Vaccines for Children Program in Puerto Rico After Hurricanes Irma and Maria, 2017-2019	North America	Puerto Rico	Observational	Descriptive	Environmental	Hurricane	Adaptiveness, Resource Availability and Access
das Neves Martins Pires (2021) ²⁵	Covid-19 pandemic impact on maternal and child health services access in Nampula, Mozambique: a mixed methods research	Africa	Mozambique	Observational	Analytical	Environmental	COVID-19 outbreak	Adaptiveness, Integration
Abid (2022) ²⁶	The Impact of COVID-19 Pandemic Lockdown on Routine Immunization in the Province of Laghman, Afghanistan	Asia	Afghanistan	Observational	Descriptive	Environmental	COVID-19 outbreak	Resource Availability and Access
Bekele (2022) ²⁷	Impact of the COVID-19 pandemic on utilisation of facility-based essential	Africa	Ethiopia	Observational	Analytical	Environmental	COVID-19 outbreak	Adaptiveness, Awareness,

	maternal and child health services from March to August 2020 compared with pre-pandemic March–August 2019: a mixed-methods study in North Shewa Zone, Ethiopia							Integration, Resource Availability and Access, Self-regulation
Carter (2022) ²⁸	Impact of the Early Stages of the COVID-19 Pandemic on Coverage of Reproductive, Maternal, and Newborn Health Interventions in Ethiopia: A Natural Experiment	Africa	Ethiopia	Observational	Analytical	Environmental	COVID-19 outbreak	Adaptiveness, Awareness, Integration, Resource Availability and Access, Self-regulation
Kim (2022) ²⁹	Universal healthcare coverage and health service delivery before and during the COVID-19 pandemic: A difference-in-difference study of childhood immunization coverage from 195 countries	Global	195 countries	Observational	Analytical	Environmental	COVID-19 outbreak	Resource Availability and Access
Mancarella (2022) ³⁰	Catch-up vaccination campaign in children between 6 and 8 years old during COVID-19 pandemic: The experience in a COVID hub in Milan, Italy	Europe	Italy	Observational	Analytical	Environmental	COVID-19 outbreak	Adaptiveness
Ryan (2022) ³¹	Challenges to Adolescent HPV Vaccination and Implementation of Evidence-Based Interventions to Promote Vaccine Uptake During the COVID-19 Pandemic: “HPV Is Probably Not at the Top of Our List”	North America	USA	Observational	Descriptive	Environmental	COVID-19 outbreak	Adaptiveness, Awareness, Integration, Resource Availability and Access, Self-regulation
Sahoo (2022) ³²	Experiences of Urban Slum-Dwelling Women With Maternal and Child Health Services During COVID-19 Pandemic: A Multi-City Qualitative Study From India	Asia	India	Observational	Descriptive	Environmental	COVID-19 outbreak	Adaptiveness, Awareness, Integration, Resource Availability and Access, Self-regulation
Shet (2022) ³³	Impact of the SARS-CoV-2 pandemic on routine immunisation services: evidence of disruption and recovery from 170 countries and territories	Global	170 countries	Observational	Analytical	Environmental	COVID-19 outbreak	Adaptiveness, Awareness, Integration, Resource Availability and Access, Self-regulation

Lucinde (2023) ³⁴	The impact of the COVID-19 pandemic on vaccine coverage in Kilifi, Kenya: A retrospective cohort study	Africa	Kenya	Observational	Analytical	Environmental	COVID-19 outbreak	Adaptiveness, Awareness, Resource Availability and Access
Martínez-Marcos (2023) ³⁵	Impact of the COVID-19 lockdown on routine childhood vaccination coverage rates in Catalonia (Spain): a public health register-based study	Europe	Spain	Observational	Analytical	Environmental	COVID-19 outbreak	Adaptiveness
Njoh (2023) ³⁶	Polio outbreaks in Cameroon following the COVID-19 pandemic	Africa	Cameroon	Observational	Analytical	Environmental	COVID-19 outbreak	Integration, Resource Availability and Access
Sato (2023) ³⁷	Measles vaccination in Brazil: where have we been and where are we going?	South America	Brazil	Observational	Analytical	Environmental	COVID-19 outbreak	Adaptiveness, Awareness, Integration, Resource Availability and Access, Self-regulation

S3. Supplementary references

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